Black Carbon Measurements in the Mountains of California: Sources and Impacts

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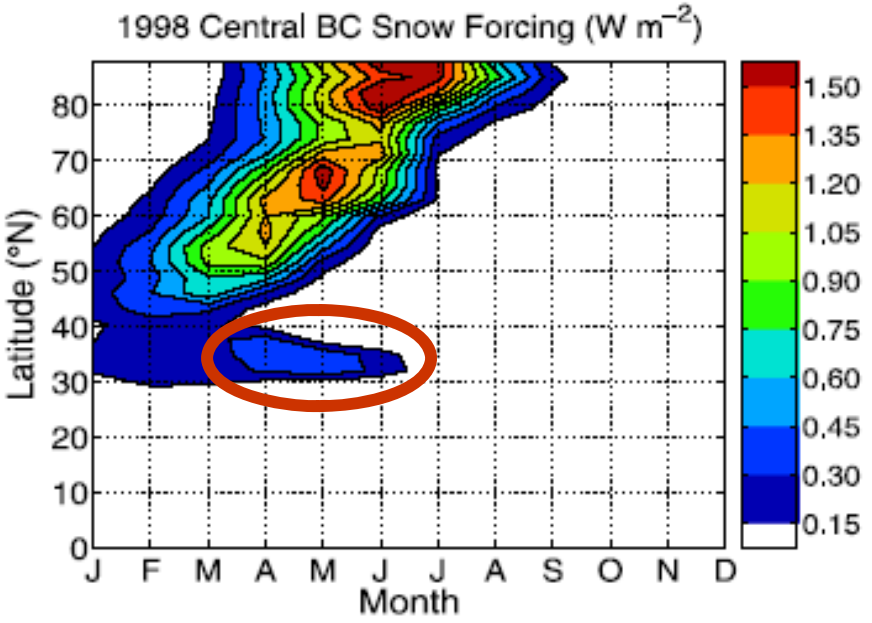
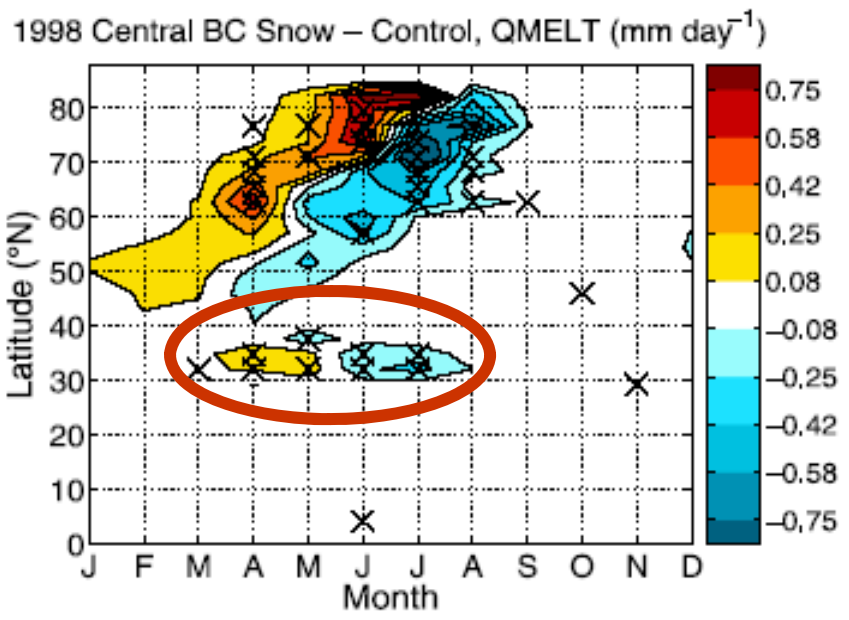
- Introduction (Motivation)
  - Black carbon on snow: Climate forcing, albedo reduction and melt
- Black Carbon (BC) sampling in California
  - Sample collection and site locations
  - Black carbon concentrations
  - Radiative impact
- Sources
  - Ambient BC and wet deposition to the snow pack.
  - Regional vs. long range transport
  - Spatial and seasonal variability

BC in snow: Climate impacts





- **Between 30N - 40N (California Mountain Latitudes) (Flanner et al., 2007):**
  - **BC forcing is important in March, April, and May**
  - **Enhanced melt rate in April and May**
  - **Less melt in June and July (summer)**

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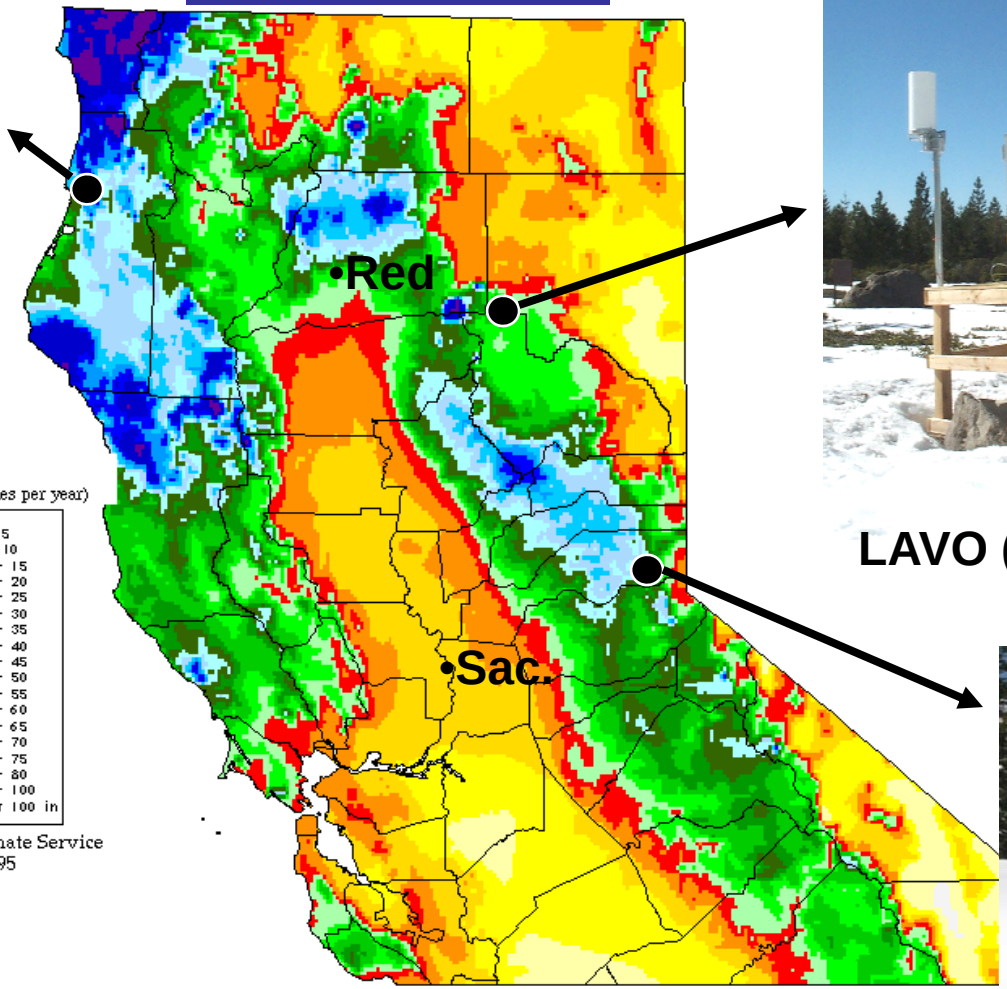
  - Regional vs. long range transport
  - Regional and seasonal trends

Wet rain and snow sampler

- Collector is automated to open and close during a precipitation event.
- Heated funnel melts the snow.
- Precipitation is collected in discrete daily samples.
- Data logger records time, intensity, and duration of each event.
- Collects up to 8 days of precipitation.

Field Sites

THD (107 m)



LAVO (1732 m)

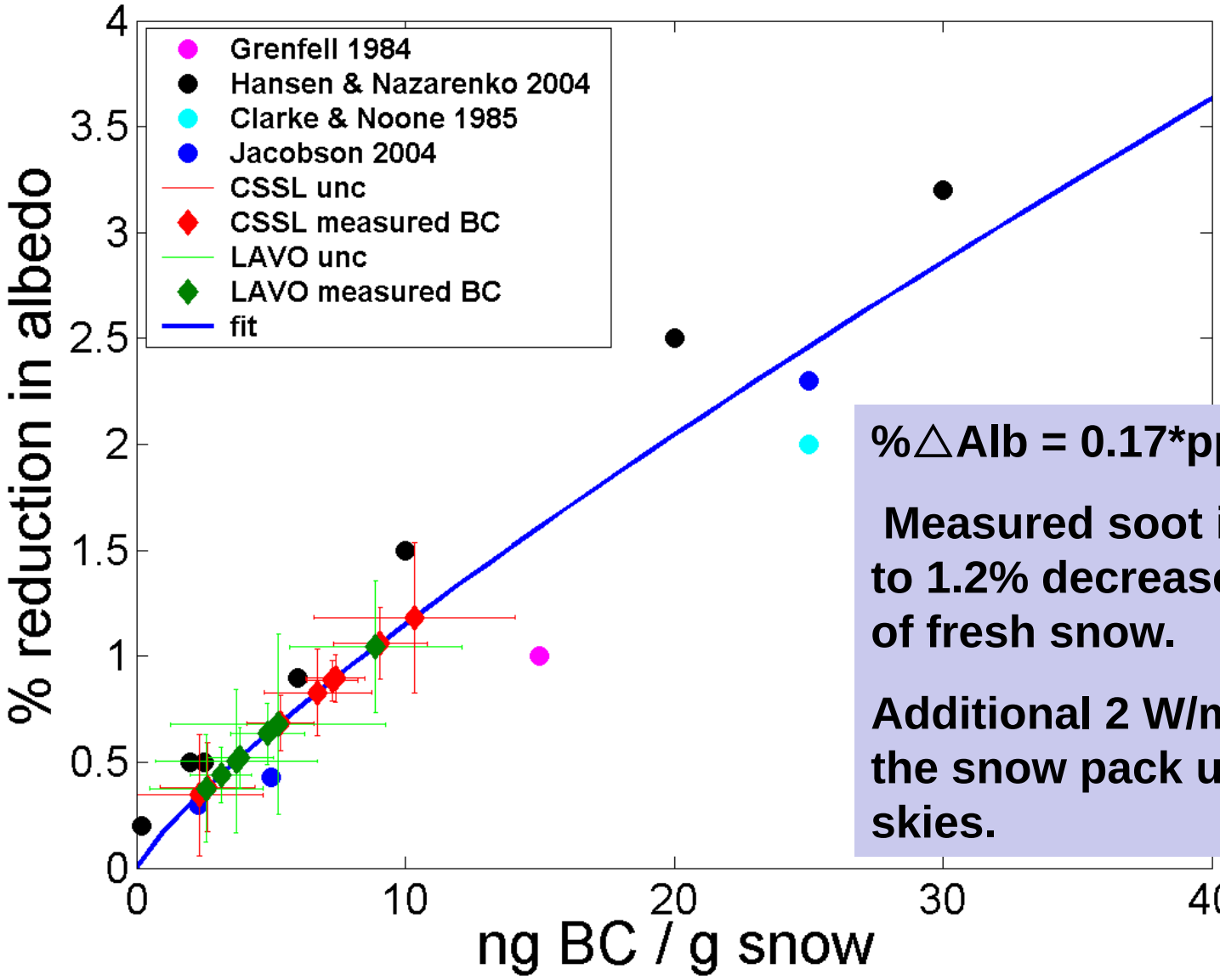
CSSL (2100 m)

http://www.wrcc.dri.edu/pcpn/ca_north.gif

Measured BC in CA precipitation

Location:	**nanograms of BC per gram of snow or rain water**
Trinidad Head	5.7 +/- 2.9
Lassen Vol. Nat. Park (LAVO)	5.3 +/- 2.9
Central Sierra Snow Lab (CSSL)	7.0 +/- 2.3

Modeled effect of BC on albedo (vis) of fresh snow



%△Alb = 0.17*ppbw $BC^{0.83}$

Measured soot indicates a 0.3 to 1.2% decrease in the albedo of fresh snow.

Additional 2 W/m^2 absorbed by the snow pack under clear skies.

Caveats

- **BC effect on snow albedo is based on model assumptions**
  1. **Need to verify albedo sensitivity to BC with measurements**
  2. **Need to determine sensitivity of melt to albedo changes**
  3. **Need to measure BC distribution in the snow pack during melt conditions**

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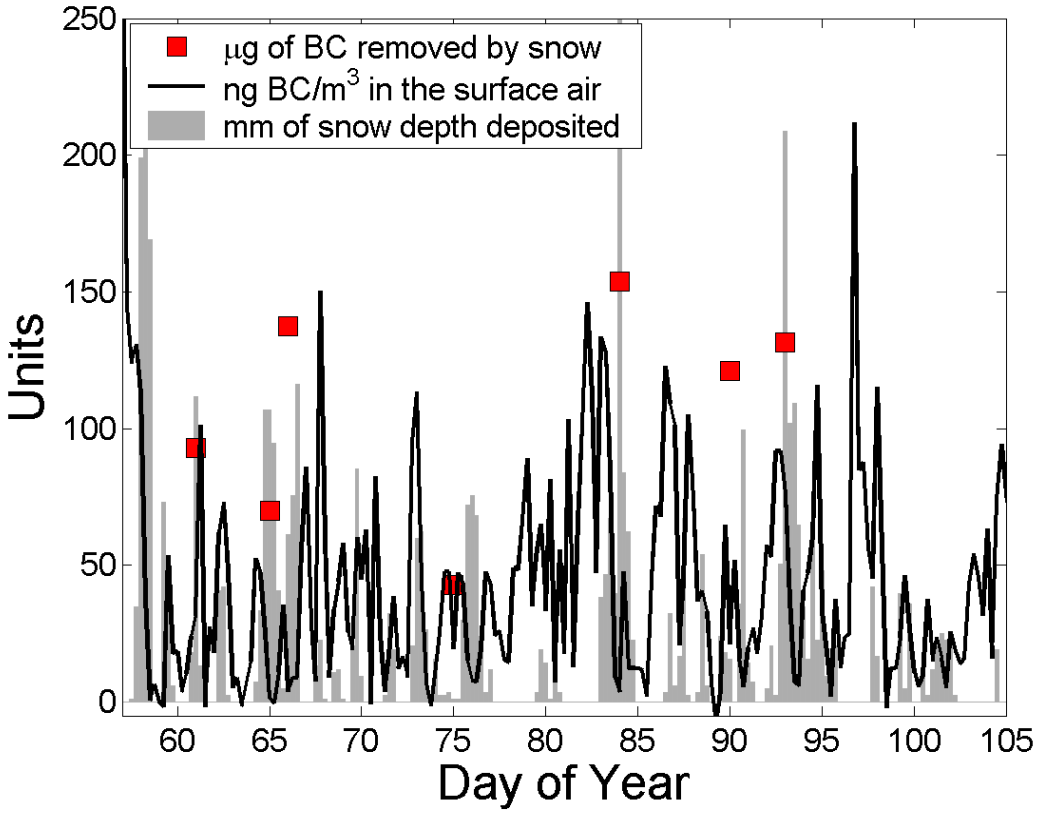
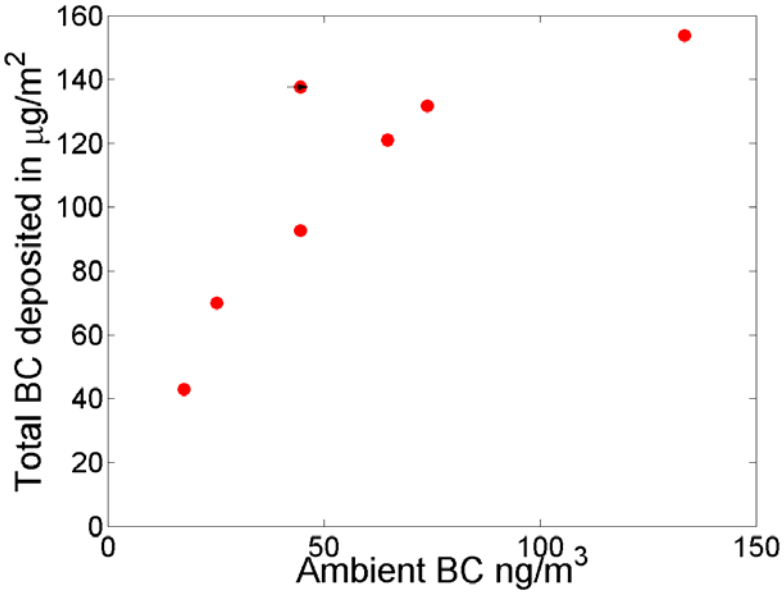
Wet removal of BC to Snow Pack at LAVO





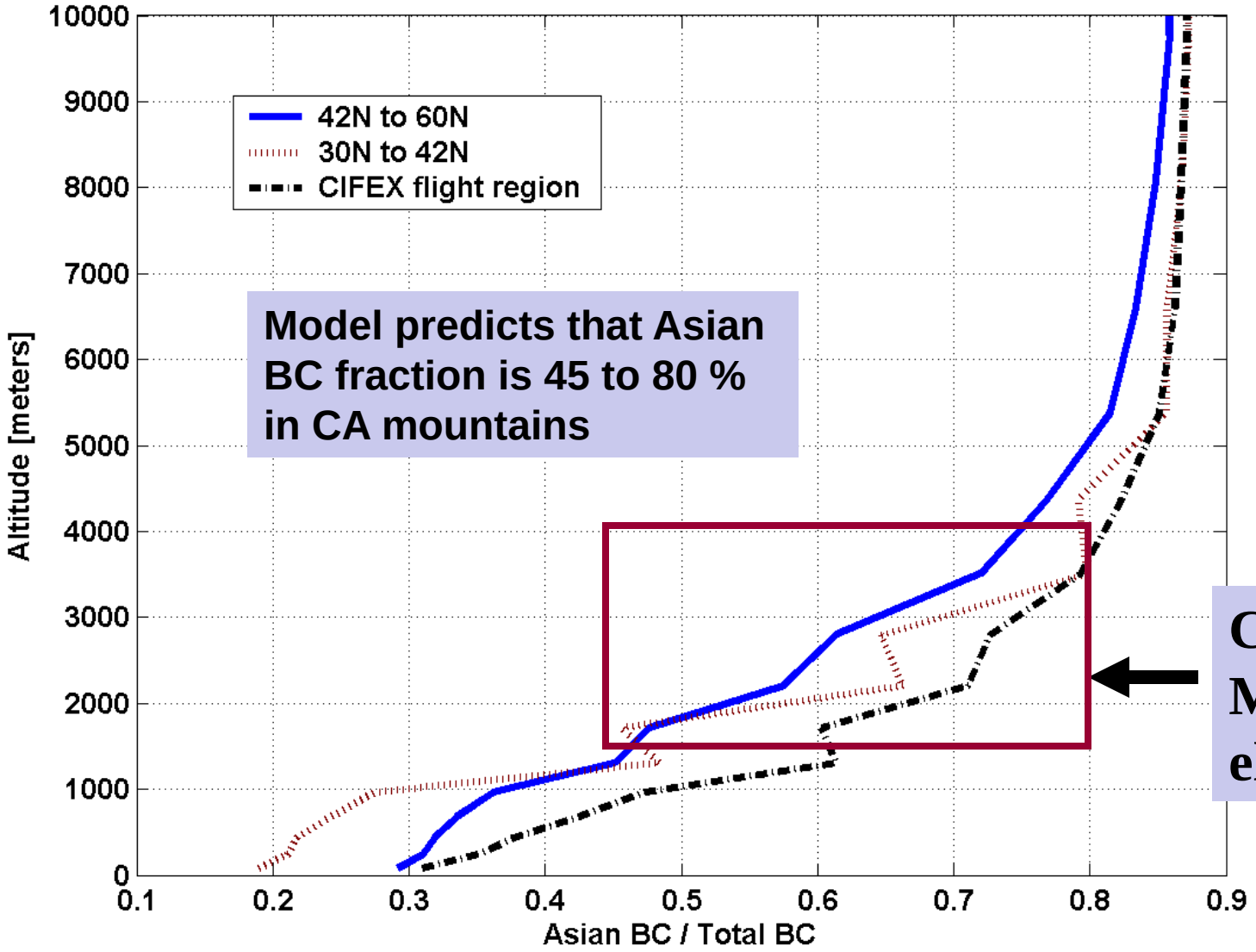
High correlation indicates that below cloud scavenging is a major source of BC in the snow,

i.e... Before it's in the snow, it's in the air!

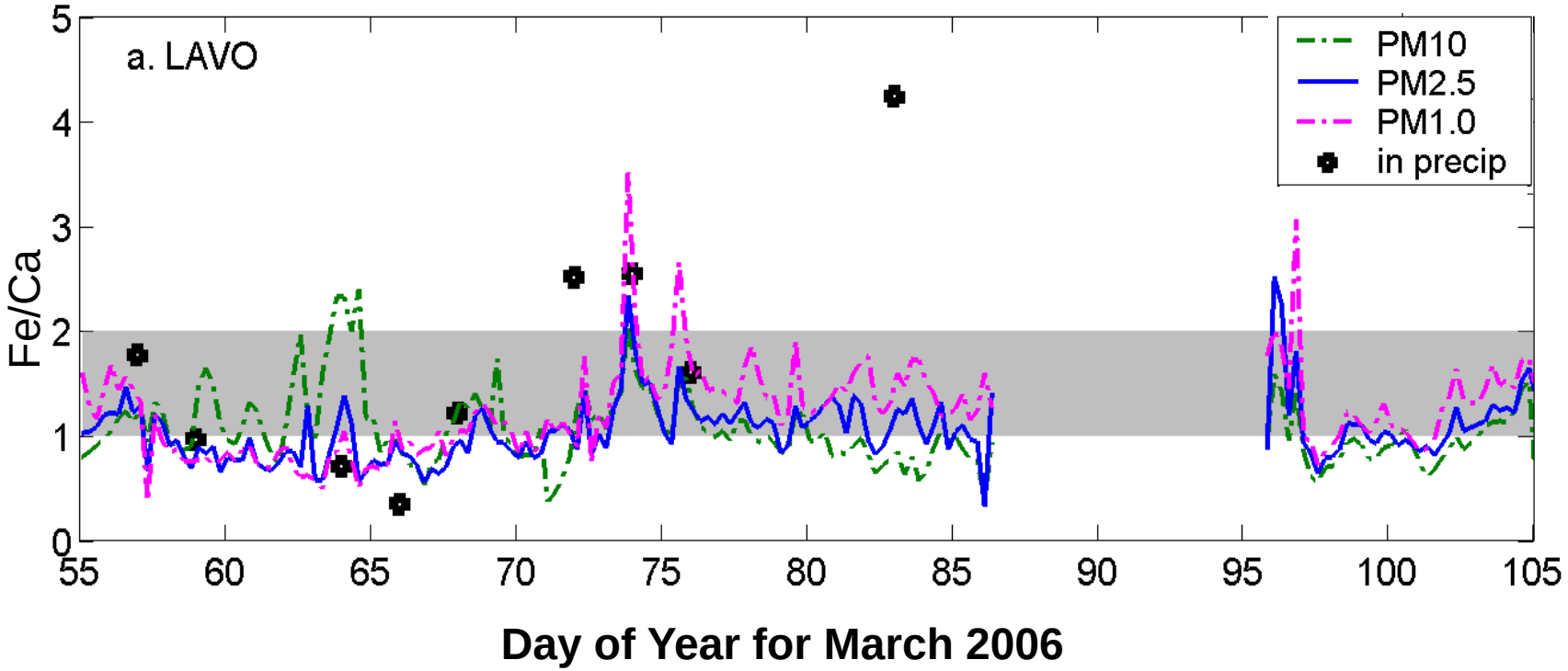
So where is it coming from???

Modeled Asian fraction of BC

(Hadley et al, 2007)



Elemental Composition of Aerosol in Precipitation and in Air



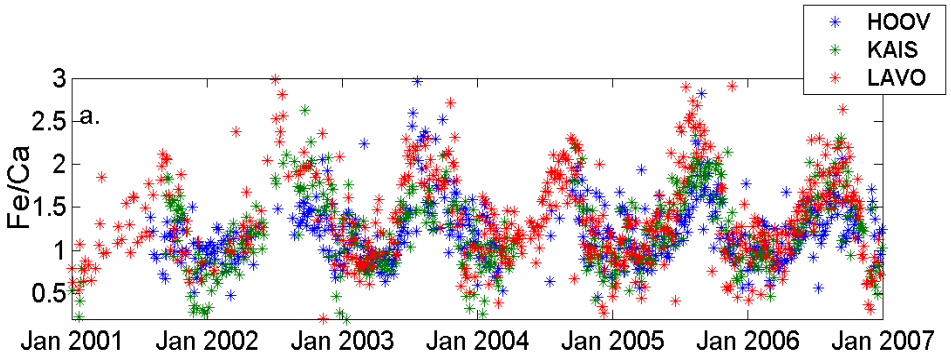
Fe/Ca< 1 indicates Asian dust *(Van Curen, 2005)*

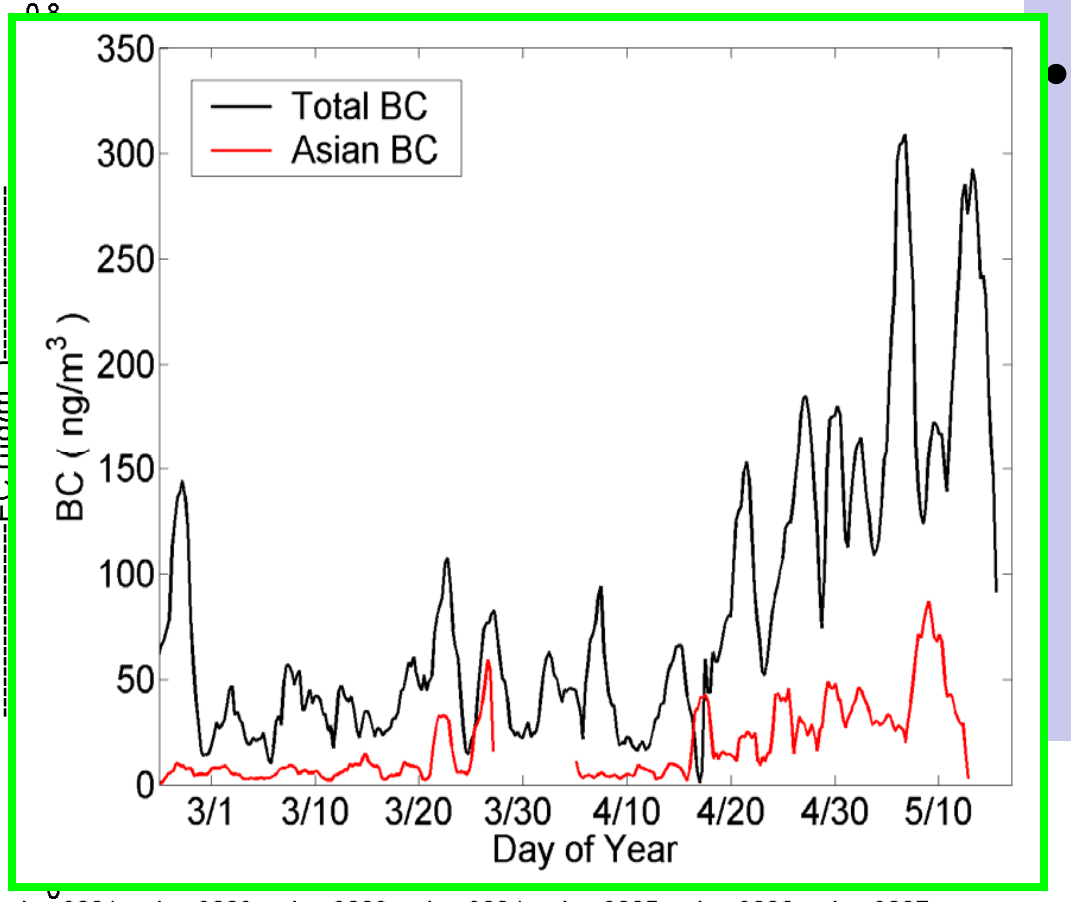
Fe/Ca> 2 indicates local/regional dust

Fe/Ca ratio in snow follows PM2.5 most closely

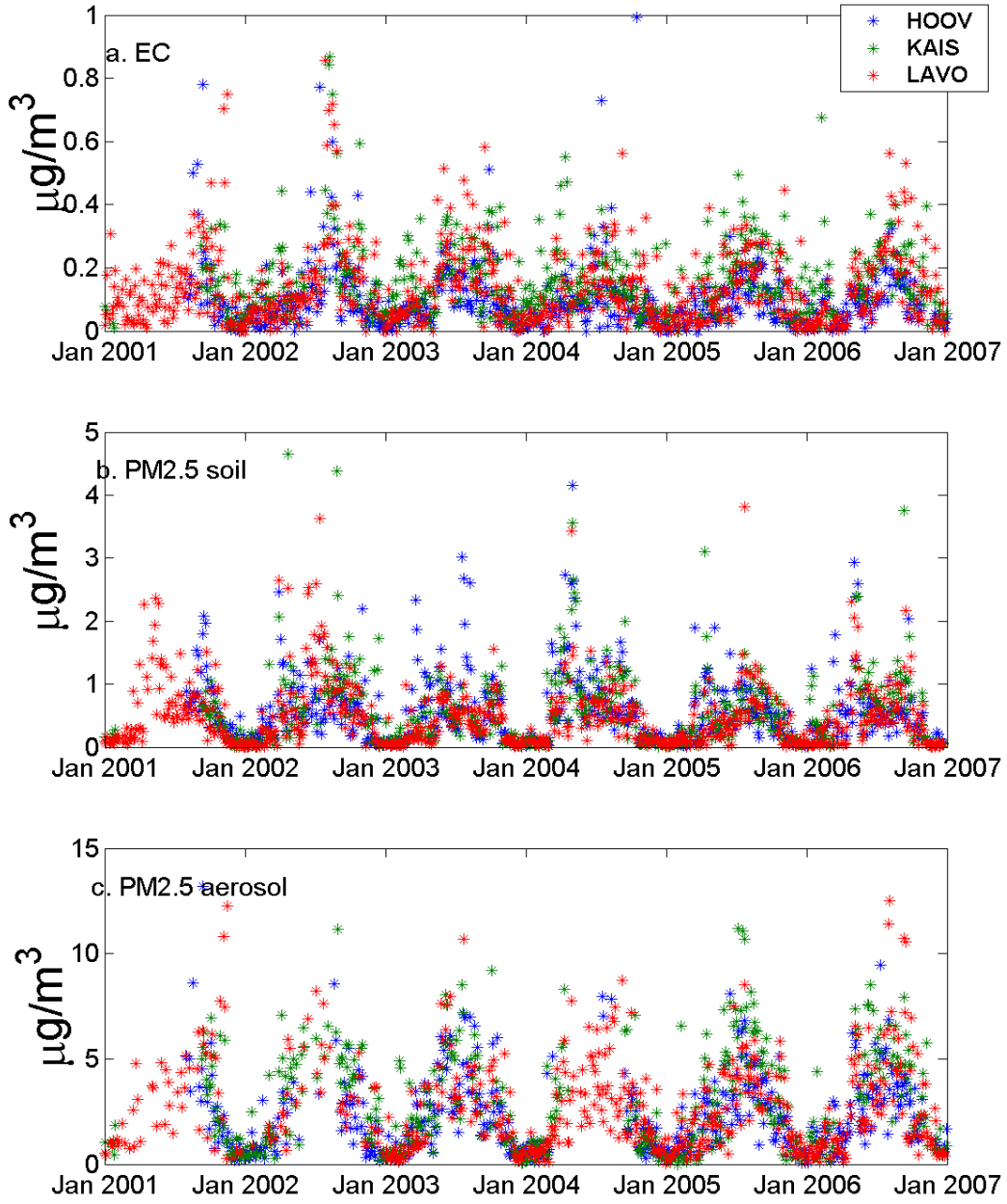
Asian fraction of observed BC

- **Use soil elemental markers to estimate Asian fraction of observed BC.**
  - **Use ratio of measured BC to PM2.5 dust at Asian sites** ***(Shen, et al., 2007; Yang, et al., 2005)***
    - **8 to 10%**
  - **Assume ratio remains constant during transport**
  - **Scale observed Asian dust fraction in California by the Asian BC to dust ratio.**





- **Estimate average springtime Asian BC at 3 sites:**
  - **HOOV is 50 ± 20%**
  - **KAIS is 15 ± 5%**
  - **LAVO is 17 ± 8%**



- LAVO is representative of other CA mountain sites.

March and April are peak dust months in Asia and low emissions in CA.

BC emissions are not as seasonally determined.

Conclusions

- **Snow effectively removes BC from the atmosphere to the snow pack**
  - This is the main source of BC in snow
- **Roughly 15 to 50% (depending on elevation) of the observed BC in CA mountains in the spring is likely due to trans-Pacific transport.**
  - Asian fraction may be less in sites directly downwind of large urban centers.
  - Total BC removed by snow at CSSL was twice that of LAVO.

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